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ABSTRACT

The "Programed Math Tutorial" is an approach to individualizing instruction through the use of tutoring by paraprofessionals and peer teaching. Designed for use in the primary grades, the program incorporates training tutors in the determination of acceptable or unacceptable answers. Tutors are given detailed instruction on the use of materials for making this determination. "No specialized knowledge of content or teaching methods is necdssary," and older children have been trained to use the materials in some situations. Three of these situations are described and compared in this paper. The individualized presentation of material by the tutor to the student involves presenting the criterion task first. If the student successfully performs this task, he moves to the next one. If not, the tutor employs "brightening" to help the child reach an acceptable response. Also, detailed record-keeping by the tutor allows a child to skip material already mastered when it occurs within a lesson. Sample pages from the "Programed Math Tutorial" are included as an appendix to this paper. (SD)

The Programed Math Tutorial -- Paraprofessionals Provide One-to-one Instruction in Primary School Mathematics

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What is the Programed Math Tutorial? Who are the tutors? In the brief time period allowed, I'd like to provide some information concerning each of these questions. But first, let me mention that the Programed Math Tutorial has been proved effective in helping primary school children learn both mathematics concepts and computational skills (Ronshausen, 1972, 1973).

The Programed Math Tutorial

The Programed Math Tutorial (PMT) has been written for primary school mathematics -- kindergarten, first and second grades. At each grade level, two sets of programs are used. The operational programs describe the tutoring strategies (how). The lesson programs describe the mathematics tasks (what). It is the tutor whose activities are programed. Because the child's activities are individualized in three ways, few children have identical mathematics instruction. (Individualization will be described later in the paper).

The teaching procedure used in the PMT is called programed tutoring. It is a combination of some principles of programed instruction and some currently-accepted classroom methods. Examples of the latter include discovery learning, one-to-one instruction, individualized instruction and activity learning; examples of the former include use of positive reinforcement, immediate knowledge of results, carefully planned learning activities, small steps to criterion behavior, explicitly-defined performance objectives and self-sufficiency in producing the desired performance outcomes.

With the programed tutoring technique, the learner is presented with the most difficult form of the task that he is expected to master at that point in the curriculum. Every acceptable response is rewarded with verbal praise (only). If the tutor concludes that a response is not acceptable, he or she employs brightening to help the child discover an acceptable response. Brightening is a process (built into each

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tutoring strategy) by which the child is guided through learning activities of gradually increasing degrees of helpfulness until he responds acceptably. These learning activities may recall to the child related mathematics tasks he has mastered, recall tool skills he possesses and/or recall physical models he has previously learned to use.

Programed tutoring is an efficient instructional method because of the brightening process built into each tutoring strategy and because of the three ways in which individualization is achieved. Within a set of content lessons, lessons the child has mastered are eliminated through the use of keyed criterion lessons;this is the first way of individualizing his mathematics instruction. Second, within a lesson, mathematics tasks the child has mastered are eliminated by a recording procedure which shows his on-going interaction with the tasks. Finally, the child progresses at his own rate, completing quickly the tasks that seem easy to him and concentrating on the more challenging tasks. There is no prescribed number of tasks or lessons to be completed in a tutoring session.

The tasks presented challenge the child to use previously-learned mathematics concepts and tool skills. The child is always doing mathematics. There are no drills or memorization lessons. He frequently uses manipulative materials, plays games and/or responds in ways which do not require writing or speaking. Programed tutoring, therefore, provides for active learning.

The child begins a set of lessons with a keyed criterion lesson. Since this lesson proceeds just like any other, the child doesn't know he is being tested. After the criterion lesson is completed, the tutor uses a chart and the keyed tasks in the lessons to select which, if any, lessons the child need not do. The tutor and child work together through the remaining lessons in order. If no lessons are needed, they go to the criterion lesson in the next lesson set.

Each lesson begins with the child attempting each task. The tutor records any unacceptable responses to the tasks and, from this list, she identifies tasks which are challenging to the child. Together, they work on these tasks until the child can respond acceptably to each of them.

A lesson ends when the child responds acceptably to every task. This may require more than one tutoring session. It is more likely that the child will complete two or three lessons in a tutoring session.

The child is tutored at a time when he will not miss mathematics instruction in the classroom. He is tutored 15 minutes each school day; this is the formal part of the tutoring session. The tutor is expected to interact informally with the child before and after the actual tutoring period. The tutor and child establish a working relationship through conversation and other ways of showing friendly interest. The tutor's disciplinary arrangement is based on this relationship rather than "authority".

Paraprofessional Tutors

The tutor is not expected to be a teacher. It would be more accurate to describe the tutor as a technician whose tutoring behaviors are defined and controlled by the operational (how to tutor) and content (what to tutor) programs. Adult paraprofessionals receive 25-30 hours of training, about one-half of it early in the school year, before tutoring begins. Each tutor is trained to use the two sets of programs, the recording procedures (including the keyed criterion lessons) and positive reinforcement.

Tutor supervision is provided by experienced tutors with special training in supervision. The tutor supervisor may also train tutors. The supervisor is a consultant rather than an administrator. He or she assists tutors in maintaining and improving tutoring skills, in solving special problems which may arise. Often, the tutor supervisor assists in establishing effective working relationships between the tutors and the professionals in the skills.

With the Programed Math Tutorial, paraprofessionals can teach primary school mathematics effectively, yet the only teacher-like judgment the tutor must make is whether or not the child's response is acceptable. Descriptions of acceptable and unacceptable responses are included in the operational programs and specific examples of correct responses are included in the content programs. Therefore, no specialized mathematics knowledge is necessary.

Peer Tutoring

Because the tutor's duties are clearly specified and described in detail and because no specialized knowledge of content or teaching methods is necessary, programed tutoring may be done by juveniles. In the remaining minutes, a few of the experimental peer tutoring projects will be described.

In each project, the tutors are children in grades 4 through high school. (The tutees are first- and second-graders. The term "cross-age tutoring" would be more appropriate, perhaps, but it is not used in connection with programed tutoring.)

Why did these school systems implement peer tutoring? In most cases, school officials were pleased with results obtained by programed tutoring but lacked funds to continue paying adult paraprofessionals, or lacked funds to implement programed tutoring in schools not eligible for federal monies.

In some school systems using paid or volunteer adult paraprofessionals, it was noticed that some tutors became much more interested in education, their own and/or their children's. They displayed increasingly more positive attitudes towards education stimulus for furthering their own education (often with the goal of a teaching career.) Some of these school systems implemented peer tutoring with the hope that tutoring would have a similar effect on the juvenile tutors.

Of the many peer tutoring projects using programed tutoring, three will be described here. Each of the three has some sort of "hard" data -- achievement test scores -- which have convinced local school officials that peer tutoring is beneficial to the tutees. The data will not be discussed here. Because programed tutoring in primary school mathematics is relatively new and still in the field test stage, only one school system has used it in a peer tutors situation. In the other two projects, children were tutored in beginning reading. (The principles and procedures of programed tutoring of beginning reading are similar to those for programed tutoring of primary school mathematics.)

Project A. Peer tutoring was attempted in one elementary school of a large suburban school system in Kentucky. Since funds were not

available to hire paraprofessionals, high school students from the school on the same street were trained as programed tutors. These were volunteers from the Beta Club; they received no compensation. About 12 tutors were involved each day. A majority of the tutors were lost at the end of each school quarter and replacements were trained. This did not seem to affect the first-graders' achievement, but the tutor supervisors (paid professionals) found their work much more complex.

Each tutor spent a double-period (about 1 1/2 hours) each school day on the project. In that time, he or she walked to/from the elementary school, tutored three children, completed all record-keeping for that day and prepared the tutoring area for the next tutor. The tutor escorted each tutee to/and from his or her classroom. The tutoring materials were used without modification and there were no changes in the tutor training procedures.

Project B. A school system in Southern Indiana uses high school seniors as tutors. During the first three years of the project, only underachieving high school students served as tutors; the effects on the tutors' attitude and achievement were investigated along with the effects on the tutees. During the last three years, one-half credit toward graduation has been given to the tutors, so all high school seniors are eligible. Since some tutors must drive as much as 11 miles to their assigned elementary school, travel expenses are reimbursed.

Forty high school students participate; each tutors six or seven children daily. Most tutees are first- or second-graders. The high school students use the programed tutoring materials without any modifications or simplifications. In most schools, the building principal supervises the tutors' work. A few schools pay an adult paraprofessional to supervise the tutors but the adult has a full tutoring load of his or her own. All tutoring in a building is completed in one two-hour block of time so that the adult paraprofessional may travel to two or more schools during the day.

The project director has found that these high school tutors prefer to work with first- and second-graders. The tutors may accept a few fourth-graders but they will resign rather than tutor only older children.

The project director believes there is a motivational effect in helping little children learn that is not obtained when tutoring older children with established reading difficulties. However, the materials and procedures were designed for first- and second-graders, so they may be less effective with older children. The tutors may observe the decreased effectiveness and react to what is, in fact, an inefficient use of their time.

The reading achievement of tutors in this project does increase. While some of the increase may be attributed to tutoring itself (that is, the tutors learn from the materials and procedures they tutor with), the effect of counseling provided for the tutors must also be considered. Each tutor is given his or her own achievement test scores and the scores are explained; additionally, each tutor is provided with a self-help plan which he or she may apt to use.

The tutors reported that development in responsibility was a major benefit of the project for them. Since they traveled between their high schools and the elementary schools in which they tutored, there were opportunities to act irresponsibility. Each year, this has been a topic of discussion among them and, so far, they have decided among themselves what the consequences of irresponsible behavior might be for themselves and for the tutoring project. No incidents have occurred.

Project C. In several elementary schools in this California city, 200 children in grades 4-6 tutor children in first and second grade. The content specialist in each building trains the tutors, who are selected by their own classroom teacher. The operational and content programs are not modified in any way. Training progresses at a slower rate, the tutors observe and practice more than adults do before tutoring begins and each tutor begins with only one tutee. Tutoring is carefully supervised by a professional teacher, usually the content specialist in the building.

Tutees are selected on the basis of their level of achievement and tutoring is provided solely for their benefit. The tutors are selected by their classroom teachers for a variety of (often unknown) reasons -- they may be high achievers, low achievers, "discipline problems"

or children who volunteer.

Changes in the tutors' classroom achievement have not been investigated. Their teachers report that these children seem "to try harder" at their own work after tutoring awhile. The teachers suggest that, as these children find they can tutor successfully, they work to be both better tutors and better students. The children say that, as tutors, they learn to be more patient, to take direction better, to keep records. Also, the tutors say that they were proud because the little children looked up to them, they learned that the little children have personalities "like everyone else" and they enjoyed helping others achieve. Some of the tutors' comments follow.

"They forget easy"

"If they read good, they like reading; if they don't read good, they don't like reading."

"I really like to tutor so I can give the kids the chanse [sic] to read, because I have never got the chanse [sic] to get a good stard [sic] in reading. So I want to give them the chanse [sic] I have not had."

"You can be the boss over the kids."

"I feel it teaches me pacience. I need to learn pacience because I have a bad temper."

"What I like about tootering is that you do not have to read yourself..."

"Sometimes when I tutor I wonder how they feel like when they miss a word."

"They learn your habits so you have to be careful that you don't goof off."

"There's nothing wrong with tutoring except when the child is in a funny mood and doesn't want to work."

The three peer tutoring projects described here seem to be typical of those using the programed tutoring technique. Each school system had used adult paraprofessionals as programed tutors; finances dictated the use of peer tutors in order to continue the tutoring project and/or expand it to include schools not eligible for federal funds.

In comparing these projects, several similarities can be found. First -- and this may be the most surprising characteristic of these projects -- the tutoring procedures and materials are used as written,

regardless of the ages or assumed abilities of the peer tutors. This is important because the programs specify in detail how tutoring is to be done and what is to be taught; the tutor is expected to follow the programs word-for-word.

A second similarity among these projects can be found in the tutor training. Because tutors must use the procedures and materials exactly as written, tutor training is essential to the effectiveness of tutoring. In each school system, tutor training is done by local professional personnel (usually, the same people later supervise the tutors' work). Training procedures and materials are the same as those used with adults. In some cases -- particularly with grade-school age tutors -- training proceeds slower than with adults. Not only are training sessions spread over a longer period of time, but less is included in each session. Peer tutors spend more time observing on-going tutoring and participate in more role-playing than adult tutor-trainees would. Also, peer tutors begin by tutoring just one child and, as they seem ready, add one tutee at a time until they have their full tutoring load. Adults begin their full tutoring load after their first 15-hour training workshop (15 hours is about one-half the training time required by adults).

A third similarity concerns the amount of supervision required by peer tutors. All project directors agree that peer tutors require more supervision than adult tutors to maintain and improve their tutoring skills. Also, the tutor supervisor must make many decisions for the peer tutor that an adult tutor would make personally or would not require. The supervisor of peer tutors must pair tutors and tutees, schedule both tutors and tutees, arrange tutor transportation, prepare all tutoring materials, accessories and tutoring stations and handle all discipline problems. The supervisor of peer tutors may have greater problems in establishing and maintaining rapport with classroom teachers and school administrators than in an adult-tutor situation. It is sometimes difficult for the latter groups to understand that peer tutoring can be effective and they may be even more apprehensive when peer tutors are themselves low achievers or "discipline problems."

Finally, all the directors of peer tutoring projects agreed that a comprehensive master plan is necessary for success and the master plan

must have several components. One component that cannot be omitted is in-service training for classroom teachers, administrators and subject matter specialists. These professionals must have some information about programed tutoring and why it is effective, how tutors and tutees will be selected, where and when tutoring will be done, why peer tutoring is begun and how the professionals will participate in the project.

Other components of the comprehensive master plan include the following: selecting tutors and tutees, tutor training, establishing tutoring stations, providing tutoring materials and incidental supplies, scheduling, providing tutor transportation, supervising tutors, testing (if needed) and evaluating the project.

In every case, peer tutoring is used to provide a benefit for the tutees -- under-achieving or low achieving children or children who obtain low readiness test scores. Benefits obtained by the peer tutors are bonuses and frequently are not investigated other than by gathering anecdotal reports. The information that is available concerning the peer tutors suggests that the benefits they receive have more to do with motivation and personality change than with academic achievement.

Using peer tutors allows these school systems to continue or extend to more children the benefits obtainable from the programed tutoring technique. Programed tutoring of primary school mathematics was described in detail earlier in this paper. By using the mathematics program and/or the reading program, the teacher can provide an effective preventative to failure. Without using his or her own time to plan and execute instruction, the teacher can assist children who have the greatest need for psychologically engineered teaching procedures, carefully designed and sequenced learning activities and personal attention.

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Basic Addition and Subtraction, Step 1

10. BASIC ADDITION AND SUBTRACTION ITEM PROGRAM

The Basic Addition and Subtraction Item Program requires the child to give a sum or difference orally when he is shown an addition or subtraction example. If he does not give an acceptable response, he is shown how to construct and use a physical model for the example.

Record errors on Step 1.

Step 1.

Step 1 requires the child to say the correct sum or difference. The instruction is given in the Tutor's Question Book and will be similar to the following examples:

"Can you read this silently to yourself and tell me the sum?"*
"Can you read this silently to yourself and tell me the difference?"*

Point to the example and read the instruction from the Tutor's Question Book. Give the child time to respond.

NOTE: If the child reads aloud, ignore his reading.

Correct	Not Correct
The child says the correct sum or difference.	The child does not respond or says the wrong sum or difference.

Addition

(See next page for subtraction prompts.)

Reinforce and go to the next item, Step 1.	Record an error.
	Point to the example and say: TELL ME HOW (MANY) IS (N) (OBJECTS) PLUS (N) (OBJECTS).*
	Put the correct number of objects under each numeral. Point to the left-hand set and say: THIS SET HAS (N) (OBJECTS). Point to the right-hand set and say: THIS SET HAS (N) (OBJECTS). PRETEND THAT WE PUT THE SETS TOGETHER. NOW, TELL ME HOW (MANY) IS (N) (OBJECTS) PLUS (N) (OBJECTS).*
	Push the two sets together or draw a ring around both sets and say: HERE ARE THE SETS PUT TOGETHER. TELL ME HOW (MANY) (OBJECTS) THERE ARE.*
	Count the objects aloud. Then say: THERE ARE (N) (OBJECTS) HERE. SO, (N) (OBJECTS) PLUS (N) (OBJECTS) IS THE SAME NUMBER AS (N) (OBJECTS). NOW YOU SAY HOW (MANY) (OBJECTS) ARE HERE.*
	If the child does not respond correctly, say: LET'S GO ON.
	Go to the next item, Step 1.

Figure 1. Example of an Operational Program for the Programed Math Tutorial

Lesson 157, Identifying Addition Examples

Tutor's Note: Show the child the picture, pointing to the sets as you read the story. Then give the child the Writing Examples and Sentences Card to write the number sentence. When the item is completed, erase the number sentence.

[Writing Examples and Sentences Card]

A. THREE AIRPLANES JUST LANDED.
ONE AIRPLANE IS COMING IN TO LAND.
WRITE THE SAME STORY WITH NUMERALS AND SIGNS.* (3 + 1)

B. TWO CARS ARE PARKED ON THE STREET.
TWO CARS DRIVE UP TO PARK BEHIND THEM.
WRITE THE SAME STORY WITH NUMERALS AND SIGNS.* (2 + 2)

C. TWO SNAKES ARE HIDING IN THE TALL GRASS.
ONE SNAKE CRAWLS OVER TO THEM.
WRITE THE SAME STORY WITH NUMERALS AND SIGNS.* (2 + 1)

D. THREE DUCKS ARE STANDING TOGETHER.
TWO DUCKS WALK OVER TO SAY "HI."
WRITE THE SAME STORY WITH NUMERALS AND SIGNS.* (3 + 2)

E. THESE TWO PUPPIES ARE ASLEEP.
THESE THREE PUPPIES ARE RUNNING
OVER TO WAKE THEM UP.
WRITE THE SAME STORY WITH NUMERALS AND SIGNS.* (2 + 3)

YOUR NOTES:

168 Example Identification
Use with Child's Math Book, pages 96-97.

Figure 2. Example of a Content Program for the Programed Math Tutorial